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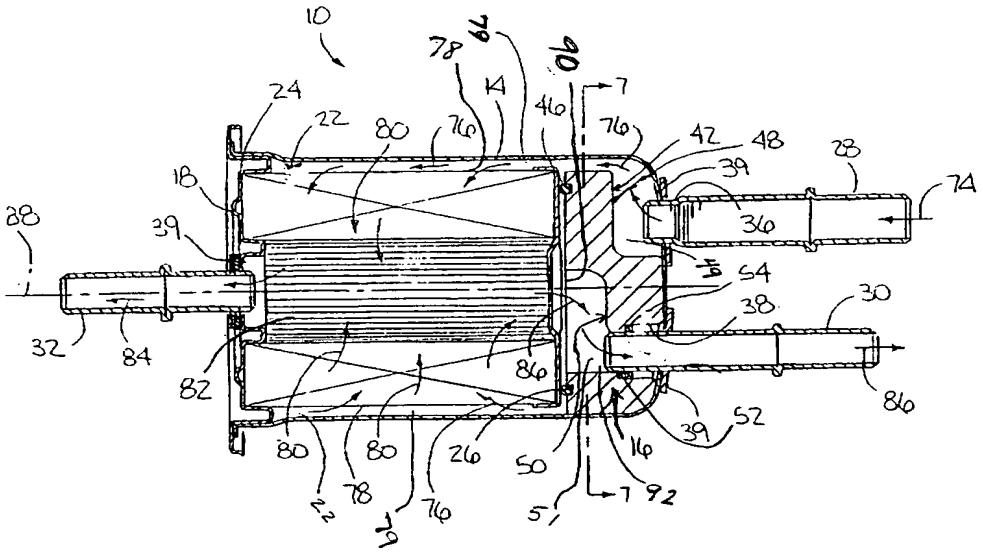
(54) Title: FUEL FILTER FLOW DIVERTER



(57) Abstract: The present invention is directed to a fuel filter (10) for use with an internal combustion engine including a housing (14) defining at least a portion of a chamber (22), a filter material (78) located within the chamber for removing impurities from the fuel and defining at least a portion of the boundary between a filtered fuel cavity (82) and an unfiltered fuel cavity (79), an inlet (28) in fluid communication with the fuel tank and the unfiltered fuel cavity (79), an engine outlet (32) in fluid communication with the filtered fuel cavity (82) and the engine, a fuel tank outlet (30) in fluid communication with the filtered fuel cavity (82) and the fuel tank, and a flow diverter (16) located within the chamber. The flow diverter defines at least a portion of a fuel flow path between the inlet (28) and the unfiltered fuel cavity (79) and between the unfiltered fuel cavity (82) and the fuel tank outlet (30).

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FUEL FILTER FLOW DIVERTER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation in part of United States provisional patent application serial No. 60/225,147 filed August 14, 2000 which is a continuation in part of United States provisional patent application no. 60/161,334 filed October 25, 1999.

FIELD OF THE INVENTION

The invention relates to an improved fuel filter for use with an internal combustion engine, such as automobile, bus, truck and boat engines as well as stationary engines.

BACKGROUND OF THE INVENTION

Fuel filters are an important part of an internal combustion engine because dirt or other contaminants in the fuel can readily cause problems if passed through to a carburetor or fuel injector in the engine. Recently, fuel injection systems have required greater pressure control and filtration of fuel for efficient operation. Consequently, pressure regulators have been combined with fuel filters as disclosed in U.S. Patent No. 5,830,348 issued to Vannoy et al. (the "'348 patent"). Such fuel filters with integral pressure regulators require an inlet from the fuel tank and an outlet to the engine as well as a return outlet which returns excess fuel to the fuel tank to maintain optimal fuel pressure in the system. The fuel filter housing of the '348 patent is formed substantially of stainless steel components, including two metal end caps. It has been found that the manufacture of such convoluted stainless steel housing and end caps to accommodate an internal pressure regulator is more expensive than desirable.

While fuel filter housings have been formed from plastic and other moldable materials, it has been found that stainless steel housings afford increased protection from stress, corrosion, and temperature extremes under certain circumstances. Thus, there is a need for a fuel filter which can accommodate an inlet and multiple outlets and is simpler and more inexpensive to manufacture. There is

further a need for a multiple inlet or outlet filter which provides increased protection from stress, corrosion, and temperature extremes.

SUMMARY OF THE INVENTION

The present invention is directed to a fuel filter for use with an internal combustion engine including: a housing defining at least a portion of a chamber, a filter material located within the chamber for removing impurities from the fuel and defining at least a portion of the boundary between a filtered fuel cavity and an unfiltered fuel cavity, an inlet in fluid communication with the fuel tank and the unfiltered fuel cavity, an engine outlet in fluid communication with the filtered fuel cavity and the engine, a fuel tank outlet in fluid communication with the filtered fuel cavity and the fuel tank, and a flow diverter located within the chamber. The flow diverter defines at least a portion of a fuel flow path between the inlet and the unfiltered fuel cavity and between the unfiltered fuel cavity and the fuel tank outlet. The use of a flow diverter in accordance with the invention in a fuel filter designed to accommodate multiple inlets or outlets permits the use of a housing and end caps of relatively simple and inexpensive design.

In one preferred embodiment of the invention, the exterior housing of the fuel filter is made from stainless steel to provide enhanced strength and corrosion resistance to the fuel filter. The flow diverter is preferably formed from a chemically stable moldable material, such as plastic or rubber, but may also be formed from metal. In this embodiment, the flow diverter is located adjacent to the fuel tank inlet and fuel tank outlet so that the inlet and fuel tank outlet can be accommodated on one end of the filter.

In another preferred embodiment of the invention, the flow diverter is press fit or insert molded to at least one end cap of the filter to provide an integrated flow diverter/end cap. In this embodiment, the integrated end cap/diverter is then affixed to the filter element. The term "fluid communication" as used herein means being capable of fluid flow between a first area and a second area whether or not the areas are separated by a valve, regulator, fuel pump or the like.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded perspective view of a fuel filter in accordance with one embodiment of the invention;

FIG. 2 is another exploded perspective view of the fuel filter of FIG. 1;

FIG. 3 is yet another exploded perspective view of the fuel filter of FIG. 1;

FIG. 4 is yet another exploded perspective view of the fuel filter of FIG. 1;

FIG. 5 is yet another exploded perspective view of the fuel filter of FIG. 1 showing certain components of the fuel filter being coupled together;

FIG. 6 is a sectional view of the fuel filter of FIG. 1;

FIG. 7 is sectional view taken along line 7-7 of FIG. 6;

FIG. 8 is a sectional view of a flow diverter in accordance with one embodiment of the invention;

FIG. 9 is a bottom view of the flow diverter shown in FIG. 8;

FIG. 10 is a sectional view of the fuel filter of FIG. 1;

FIG. 11 is a sectional view of a second version of another embodiment of the fuel filter in accordance with the invention;

FIG. 12 is a top plan view of the flow diverter and end cap of FIG. 11;

FIG. 13 is a section taken along line A-A of FIG. 12 showing the flow diverter and an end cap of FIG. 11;

FIG. 14 is a perspective view of the flow diverter and end cap shown in FIGS. 11 and 12;

FIG. 15 is a plan view of the flow diverter of FIG. 11;

FIG. 16 is a bottom plan view of the flow diverter of FIG. 11;

FIG. 17 is a section taken along line A-A of FIG. 16;

FIG. 18 is a section taken along line B-B of FIG. 15;

FIG. 19 is plan view of the end cap of FIG. 11;

FIG. 20 is a section taken along line A-A of FIG. 19; and

FIG. 21 is a detail view of detail B (scale 8:1) in FIG. 20.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A fuel filter 10 in accordance with one preferred embodiment of the invention is shown in FIGS. 1-10. The fuel filter 10 generally includes a filter element 12, an outer housing 14, and a flow diverter 16. The filter element is encased by first and second end plates 18, 20. The outer housing 14 and second end plate 18 define a chamber 22 in which filter element 12 and flow diverter 16 are positioned to lie. As best shown in FIGS. 5 and 6, the first and second end plates 18, 20 abut opposing ends 24, 26 of filter element 12. Fuel tank inlet 28 and outlets 30, 32 are provided to transfer fuel to the remainder of the fuel system.

More specifically, "dirty" fuel enters fuel filter 10 from tank line (not shown) into fuel tank inlet 28 as can be seen in FIGS. 6 and 10. The fuel is cleaned in fuel filter 10, and the "clean" or "filtered" fuel leaves fuel filter10 through fuel tank outlet 30 and engine outlet 32. The fuel tank outlet 30 and engine outlet 32 transfer fuel from the fuel filter 10 to the fuel tank (not shown) and an engine (not shown) via a tank return line (not shown) and an engine fuel line (not shown), respectively. A fuel regulator (not shown) controls the amount of clean fuel sent to the engine. Typically, the fuel regulator will be located downstream of the filter 10 along the engine line to control the amount of clean fuel received through the engine from outlet 32 and engine line. The remainder of the clean fuel not sent to the engine is returned to the fuel tank through fuel tank outlet 30 and return tank line (not shown).

As shown in FIG.6, each of the inlet 28 and outlet 30 and 32 are coupled to the fuel filter 10 in a similar fashion. The outer housing 14 and first end plate 18 are formed to include first, second, and third openings 34, 36, 38 through which inlets 28 and outlets 30, 32 extend. The first opening 34 is formed in first end plate 18 and receives engine outlet 32. The second and third openings 36, 38 are formed in outer housing 14 and receive fuel tank inlet and outlets 28, 30, respectively. In the embodiment shown in FIGS. 1-10, the housing 14, second end plate 18, inlet 28, and outlets 30, 32 are preferably formed from stainless steel. The housing and second end plate may optionally be formed from chemically inert moldable materials such as plastic or from other corrosion resistant metals such as aluminum, nickel and zinc or alloys thereof, or from other metals which have been provided with a corrosion-resistant coating such as galvanized steel or the like. In the illustrated

embodiment of FIGS 1-9, stainless steel washers 39 are provided adjacent to the openings 34, 36, 38 and the washers 39, inlet 28 and outlet 30 are brazed to first end plate 18, and outlet 32 is brazed to outer housing 14. Alternatively, the inlet and outlets may be integrally formed in the outer housing and end plate as shown in second end plate 18 in FIG. 10.

As can be best seen in FIGS. 5, 6 and 8, the flow diverter 16 is generally cylindrically shaped and includes a first side 40 facing toward filter element 12 and a second side 42 facing away from first side 40. The first side 40 is formed to include a channel 44 extend around the circumference of the first side 40, and the fuel filter 10 includes an o-ring or seal 46 positioned to lie in channel 44 as best illustrated in FIGS. 2 and 3. The flow diverter 16 is positioned to lie in chamber 22 of outer housing 14 so that o-ring 46 abuts second end plate 20 mounted to the filter element 12 to provide a seal between flow diverter 16 and second end plate 20.

As shown in FIGS. 6 and 8, the flow diverter 16 further includes an fuel inlet-receiving region 48, a fuel outlet-receiving region 50, and a fuel tank outlet passageway 52. The flow diverter 16 is positioned to lie in chamber 22 so that fuel inlet-receiving region 48 is adjacent to fuel tank inlet 28 and defines fuel inlet compartment 49 together with the outer housing 14 as seen in FIG. 6. The fuel outlet-receiving region 52 is positioned adjacent to opening 38 and defines a fuel outlet compartment 51. The fuel tank outlet 30 is positioned to extend through fuel tank outlet passageway 52. The fuel filter 10 further includes an o-ring or seal 54 that abuts a shoulder 56 formed in passageway 52. The o-ring 54 provides a seal between fuel tank outlet passageway 52 and fuel tank outlet 30. In preferred embodiments, the flow diverter 16 is made from a moldable material such as plastic or rubber. However, it is also contemplated that the flow diverter may be made from other chemically stable materials such as metal.

The fuel filter 10 and outer housing 14 are substantially circular in cross-section as shown in FIG. 7. As also shown in FIG. 7, the flow diverter 16 includes first and second portions 58, 60. The first portion 58 is substantially semi-circular in shape and includes a radius 62 so that an outer surface 64 of first half of flow diverter 16 is substantially concentric with outer housing 14. The radius 62 is measured from a centerline or longitudinal axis 88 of fuel filter 10 and filter element

12. The outer surface 64 of second portion 60 of flow diverter 16 includes first and second substantially straight line sections 66, 68 and a curved section 70 positioned to lie between the straight line sections 66, 68. The curved section 70 includes a radius 72 that is larger than radius 62. This larger radius 72 causes curved section 70 to abut outer housing 14 and combined with the contacting relationship between the passageway 52 and fuel tank outlet 30 substantially prevents relative movement of flow diverter 16 and outer housing 14. The straight line sections 66, 68 are required to connect the larger radius curved section 70 and the smaller radius first portion 58.

Dirty fuel flows in direction 74 into the chamber 22 generally defined by outer housing 14 and end cap 18 through fuel tank inlet 28 that extends through opening 36 of outer housing 14. The fuel first enters the fuel inlet compartment 49 of the cavity 22. The fuel then flows in direction 76 through chamber 22 about an outer or exterior surface 78 of filter element 12. The portion of the chamber 22 that is upstream of the boundary defined by the exterior surface 78 of the filter element 12 is the unfiltered fuel cavity 79 of the fuel filter 10. The dirty fuel is "cleaned" as it then flows in direction 80 through filter element 12 into an interior region 82 of filter element 12. From the interior region 82 of filter element 12, the fuel flows in direction 84 toward and through engine outlet 32 and direction 86 toward and through fuel outlet-receiving region 50 and fuel tank outlet 30. The portion of the chamber 22 that is downstream of the filter element 12 is the filtered fuel cavity 81 of the fuel filter 10. The flow regulator controls the amount of clean fuel which flows in direction 84 to the engine and direction 86 to the fuel tank. In alternative embodiments, the fuel could flow from the interior region of the filter element to the outer surface of the filter element.

The filter element 12 includes a suitable filter material which allows liquid fuel to pass through to the interior region 82, but which prevents contaminants from passing into the interior region 82. The preferred filter material is corrugated paper, but other filter materials may be used. In the embodiment illustrated in FIGS. 1-11, the end caps 18, 20 retain the filter material and form a sealing relationship with other portions of the outer housing 14. It is also contemplated that the flow diverter of the invention may be integrated with a separate end cap or formed and dimensioned to retain the filter material in the manner of an end cap.

The fuel outlet-receiving region 50 of flow diverter 16 extends from a location adjacent to the interior region 82 of filter element 112 to a location spaced-apart from the longitudinal axis 88. In the illustrated embodiment, the fuel outlet-receiving region 50 along with the second end plate 20 defines a fuel outlet compartment 51 that extends substantially transversely relative to the longitudinal axis 88. This compartment 51 includes a first end 90 adjacent to the location where clean fuel exits filter element 12 and a second end 92 spaced apart from longitudinal axis 88. The fuel tank outlet passageway 52 communicates with compartment 51, and thus, fuel tank outlet 30, which extends into passageway 52, communicates with compartment 51.

The flow diverter 16 diverts the flow of fuel to permit two fuel lines to couple to an inlet and outlet on the same side, end, or region of outer housing 14. In the embodiment of FIGS. 1-10, the outlet and inlet are offset from centerline 88 of fuel filter 10 and filter element 12. The tank line (not shown) and return line (not shown) couple to the same region of outer housing 14 at inlet 28 and an outlet 30, respectively. In addition, in the illustrated embodiment, the inlet 28 and outlet 30 both extend between fuel filter 10 and the fuel tank. In addition, the inlet 28 transfers dirty fuel to fuel filter 10 and the outlet 30 transfers clean fuel away from fuel filter 10. The fuel filter 10 thus provides for a return of fuel to the fuel tank in addition to a supply of clean fuel to the engine.

Another embodiment of the filter of the invention is shown, for example, in FIGS.11-21. This filter 110 is similar in many respects to that shown and described in FIGS. 1-10 above differing chiefly in the design of the flow diverter 116 and the second end cap 120. In general, the flow diverter 116 differs in being designed to be press-fit or insert-molded onto the second end cap 120 which is later affixed to filter element 112. This arrangement has been used instead of the o-ring seal 46 and separate second end cap 20 shown in FIGS. 1-10.

The fuel filter 110 generally includes a filter element 112, an outer housing 114, and a flow diverter 116 as best seen in FIG. 11. The filter element is encased by first and second end plates 118, 120. The outer housing 114 and second end plate 118 define a chamber 122 in which filter element 112 and flow diverter 116 are positioned. Fuel tank inlet 128 and outlets 130, 132 are provided to transfer fuel

to and from the remainder of the fuel system in the same manner as described for the embodiment of FIGS. 1-10.

"Dirty" fuel enters fuel filter 110 from tank line (not shown) into fuel tank inlet 128. The fuel is cleaned in fuel filter 110, and the "clean" or "filtered" fuel leaves fuel filter110 through fuel tank outlet 130 and engine outlet 132. A fuel regulator (not shown) controls the amount of clean fuel sent to the engine through the engine outlet 132 and engine line. The remainder of the clean fuel not sent to the engine is returned to the fuel tank through fuel tank outlet 130 and return tank line (not shown).

As shown in FIG. 11, the inlet 128 and outlet 130 are coupled to the fuel filter 110 in a similar fashion as described above for the embodiment of FIGS. 1-10. The outer housing 114 and first end plate 118 are formed to include first, second, and third openings 134, 136, 138. The first opening 134 is formed in first end plate 118 and is defined by an integrally formed outlet 132. The second and third openings 136, 138 are formed in outer housing 114 and receive fuel tank inlet and outlets 128, 130, respectively. In the embodiment shown in FIGS. 11-21, the housing 114, second end plate 118, inlet 128 and outlet 130 are preferably formed from stainless steel. As shown in FIG. 11, stainless steel washers 139 are provided adjacent to the openings 136, 138 and the washers 139, inlet 128 and outlet 130 are brazed to outer housing 14. Alternatively, the inlet 128 and other outlet 130 may be integrally formed in the outer housing 114, and outlet 132 may be a separate piece brazed to end plate 118.

As can be best seen in FIGS. 11 and 13, the flow diverter 116 is generally disk shaped and includes a first side 140 facing toward filter element 112 and a second side 142 facing away from first side 140. The first side 140 is formed to include a downwardly extending lip 144 formed about the periphery of the first side 140 of the flow diverter. The lip 144 has an interior surface 145 and an exterior surface 147. The surface 145 has an interior diameter dimension 153 which closely matches the exterior diameter dimension of the end cap 120. The lip 144 extends around the exterior of the end cap 120 and first surface 119 of filter material of filter element 112. The flow diverter 116 is press fit onto the end cap 120 so that annular stop surface 143 abuts second end plate 120 which is later affixed to the filter element

112. The tight fit of the lip 144 and end plate 120 to provide a seal between flow diverter 116 and second end plate 120.

The second end cap 120 is preferably formed of metal, and the diverter 116 is press fit or insert molded to the metal end cap. As seen in FIGS. 19-21, end plate 120 has a disk-shaped portion 119 and an interior funnel-shaped portion 121. The funnel-shaped portion 121 has frusto-conical portion 123 and cylindrical portion 125. As seen in FIG. 11, funnel-shaped portion 119 projects into the interior 182 of the filter element 112. This integrates the end cap 120 with the diverter 116 to ease assembly of the fuel filter 110. The end cap 120 and integrated diverter 116 can then be attached to the filter element 112 preferably by melt adhesion of the metal end cap 120 against a moldable material on the end of the filter material of the filter element 112 or by applying an adhesive material to the ends of the filter material and end cap 120. Alternatively, the flow diverter may be affixed directly to the filter material of the filter element 112 to act as both a flow diverter and end cap.

As shown in FIG. 13, the flow diverter 116 further includes an fuel inlet-receiving region 148, a fuel outlet-receiving region 150, and a fuel tank outlet passageway 152. As seen in FIG. 11, the flow diverter 116 is positioned to lie in chamber 122 so that fuel inlet-receiving region 148 is adjacent to fuel tank inlet 128 and defines fuel inlet compartment 149 together with the outer housing 114. The fuel outlet-receiving region 150 is positioned adjacent to opening 138 and defines a fuel outlet compartment 151 together with end plate 120. The fuel tank outlet 130 is positioned to extend through fuel tank outlet passageway 152. As best seen in FIG. 17, the fuel filter 110 further includes an o-ring or seal 154 that abuts a channel 156 formed in passageway 152. The o-ring (not shown) provides a seal between flow diverter 116 and fuel tank outlet passageway 152.

The fuel filter diverter 110 and end cap 120 are substantially circular in cross-section as shown in FIG. 12. The diverter 116 includes a radius dimensioned so that an outer surface 147 of the diverter 116 is substantially concentric with end plate 120 and outer housing 114. The flow diverter 116 may optionally include a projection from outer surface 147 with a larger dimensioned radius to abut outer housing 114. The contact between the optional projection and housing 114 may be included to

impede relative rotation of flow diverter 116 relative to the longitudinal axis defined by the tank outlet 138 and tank outlet passageway 152.

The flow path within the fuel 110 is substantially the same as the flow path described above for the embodiment of FIGS. 1-10. The fuel outlet-receiving region 150 of flow diverter 116 extends from a location adjacent to the interior region 182 of filter element 112 to a location spaced-apart from the longitudinal axis 188. In the illustrated embodiment, the fuel outlet-receiving region 150 along with the second end plate 120 defines a fuel outlet compartment 151 that extends substantially transversely relative to the longitudinal axis 188. This compartment 151 includes a first end 190 adjacent to the location where clean fuel exits filter element 112 and a second end 192 spaced apart from longitudinal axis 188. The fuel tank outlet passageway 152 communicates with compartment 151, and thus, fuel tank outlet 130, which extends into passageway 152, communicates with compartment 151.

The applicant has provided description and figures which are intended as an illustration of certain embodiments of the invention, and are not intended to be construed as containing or implying limitation of the invention to those embodiments. It will be appreciated that, although applicant has described various aspects of the invention with respect to specific embodiments, various alternatives and modifications will be apparent from the present disclosure which are within the spirit and scope of the present invention as set forth in the following claims.

CLAIMS

What is claimed:

1. A fuel filter for use with a combustion engine having a fuel tank and an engine comprising:

a housing defining at least a portion of a chamber;

a filter element located within said chamber for removing impurities from the fuel, said filter element defining at least a portion of a boundary between a filtered fuel cavity and unfiltered fuel cavity;

an inlet in fluid communication with the fuel tank and said unfiltered fuel cavity;

an engine outlet in fluid communication with said filtered fuel cavity and the engine;

a fuel tank outlet in fluid communication with said filtered fuel cavity and the fuel tank; and

a flow diverter located within said chamber.

2. The fuel filter of Claim 1 wherein said housing is formed primarily from metal.

3. The filter of Claim 1 wherein at least a portion of said unfiltered fuel cavity is defined by a flow diverter located within said chamber.

4. The fuel filter of Claim 1 wherein at least a portion of said unfiltered fuel cavity is defined by a flow diverter located within said chamber.

5. The fuel filter of Claim 1 wherein said flow diverter includes a first surface formed to define at least a portion of a fuel inlet compartment within said chamber.

6. The fuel filter of Claim 1 wherein said flow diverter includes a second surface having at least one portion formed to define at least a portion of a fuel outlet compartment within said chamber.

7. The fuel filter of Claim 1 wherein said second surface of said flow diverter has at least one portion formed to define a fuel tank outlet receiving passage way.

8. The fuel filter of Claim 7 wherein said tank outlet receiving passage way includes an O-ring retaining surface.

9. The fuel filter of Claim 1 wherein said flow diverter includes a lip dimensioned to receive an end cap and wherein said filter material is retained by an end cap dimensioned for inserting into said lip.

10. The fuel filter of Claim 1 wherein said flow diverter includes a channel for receiving an O-ring and said fuel filter further includes an O-ring for providing a seal between said flow diverter and said filter element.

11. A fuel filter for use with a combustion engine having a fuel tank and an engine comprising:

a housing defining at least a portion of a chamber;

a filter material located within said chamber for removing impurities from the fuel, said filter material defining at least a portion of a boundary between a filtered fuel cavity and unfiltered fuel cavity and having first and second ends;

at least one end cap affixed to one of first and second ends of said filter material;

an inlet in fluid communication with the fuel tank and said unfiltered fuel cavity;

an engine outlet in fluid communication with said filtered fuel cavity and the engine;

a fuel tank outlet in fluid communication with said filtered fuel cavity and the fuel tank; and

a flow diverter located within said chamber.

12. The fuel filter of Claim 11 wherein said flow diverter includes a channel for receiving an O-ring and wherein said fuel filter further comprises an O-ring for providing a seal between said flow diverter and said end cap.

13. A fuel filter of Claim 11 wherein said at least one end cap is formed of metal and is affixed to said filter material.

14. The fuel filter of Claim 11 wherein said flow diverter includes a lip dimensioned to receive said at least one end cap and wherein said end cap is dimensioned for inserting into said lip.

15. The flow diverter of Claim 11 wherein said flow diverter includes a lip extending from the periphery of said flow diverter and being dimensioned to receive one end of the filter material whereby said flow diverter retains and seals one end of the filter material.

16. A flow diverter for use in a fuel filter including a housing defining at least a portion of a chamber, a filter material located within said chamber for removing impurities from the fuel, said fuel material defining at least a portion of a boundary between a filtered fuel cavity and unfiltered fuel cavity, an inlet in fluid communication with the fuel tank and said unfiltered fuel cavity, an engine outlet in fluid communication with said filtered fuel cavity and the engine, a fuel tank outlet in fluid communication with said filtered fuel cavity and the fuel tank, said flow diverter comprising:

a first surface defining at least a portion of said unfiltered fuel cavity;

a second surface defining at least a portion of said filtered fuel cavity; and,

a fuel tank outlet passageway passing through said diverter for receiving the fuel tank outlet.

17. The flow diverter of Claim 16 wherein said second surface includes a channel for receiving an O-ring for providing a seal between said flow diverter and the filter element.

18. The flow diverter of Claim 16 wherein said fuel tank outlet passageway includes an O-ring retaining surface for receiving an O-ring to provide a seal between said fuel tank outlet passageway and said fuel outlet tank.

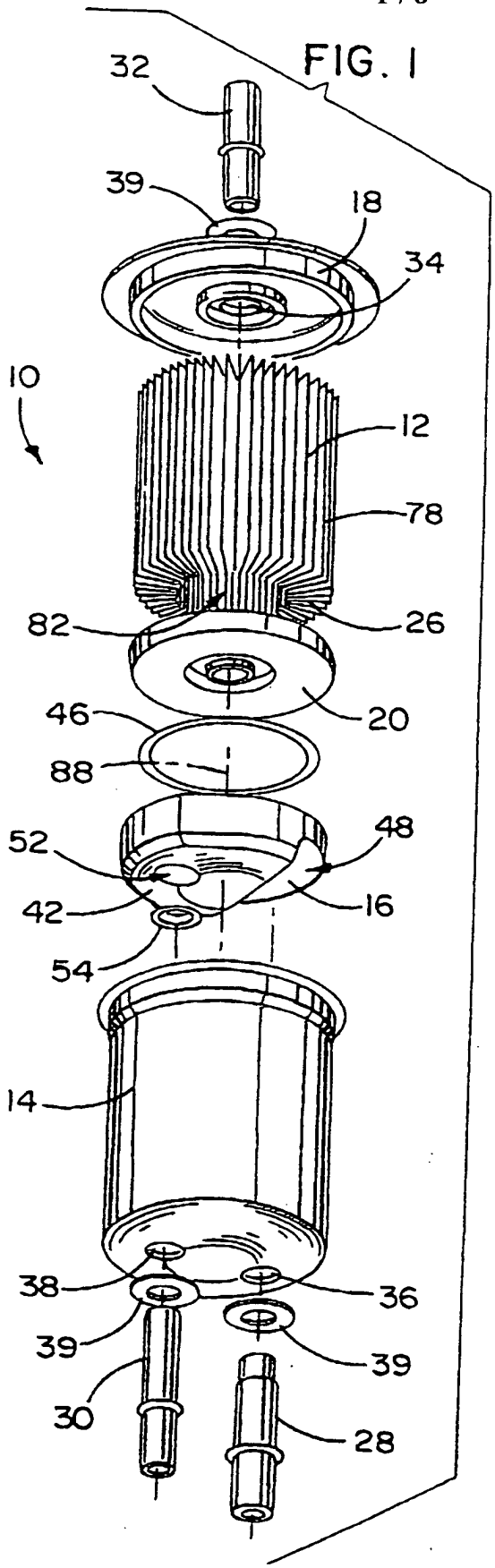
19. The flow diverter of Claim 16 wherein said O-ring retaining surface is a shoulder formed in said fuel tank outlet passageway.

20. The flow diverter of Claim 16 wherein said second surface includes a lip extending from the periphery of said second surface and being dimensioned to receive an end cap adapted to be affixed to the filter material.

21. The flow diverter of Claim 16 wherein an end cap is received in said lip and integrally affixed to said second surface of said diverter.

22. The flow diverter of Claim 16 wherein said second surface includes a downwardly extending lip dimensioned to receive one end of the filter material whereby said flow diverter retains and seals one end of the filter material.

FIG. 1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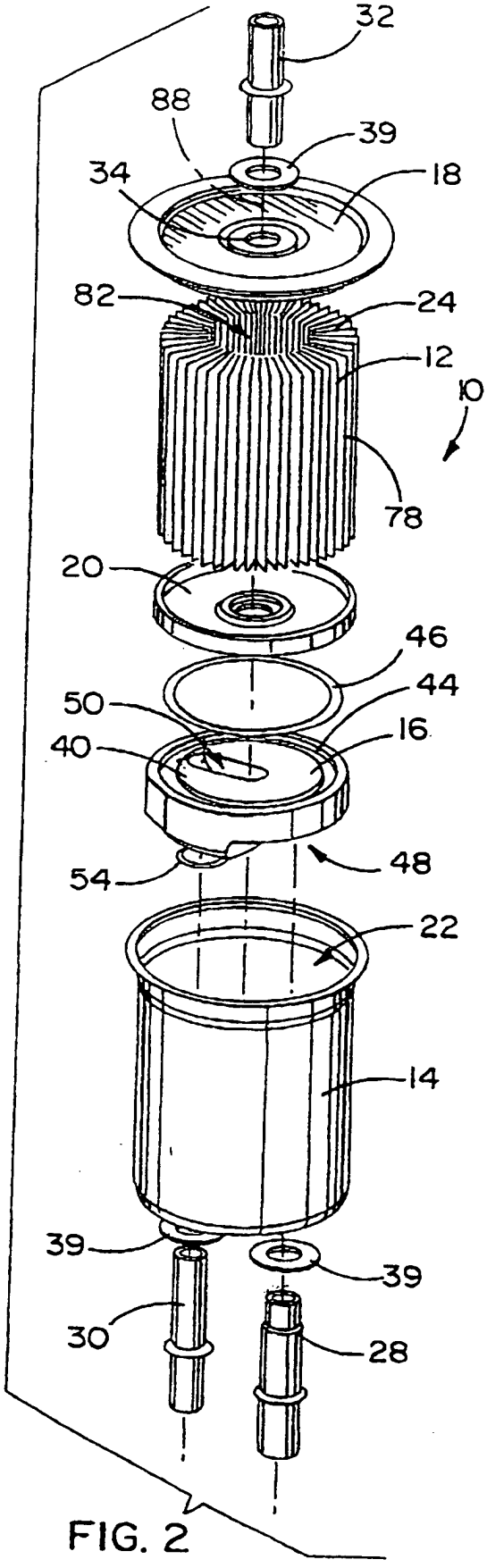
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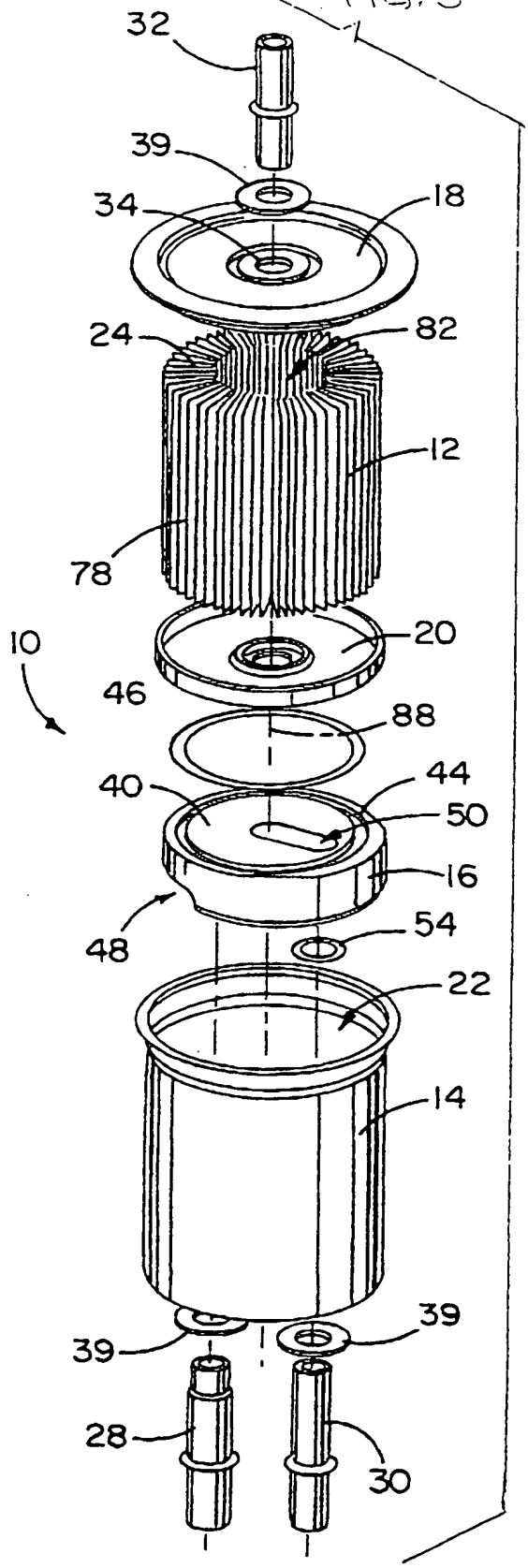
FIG. 2

FIG. 3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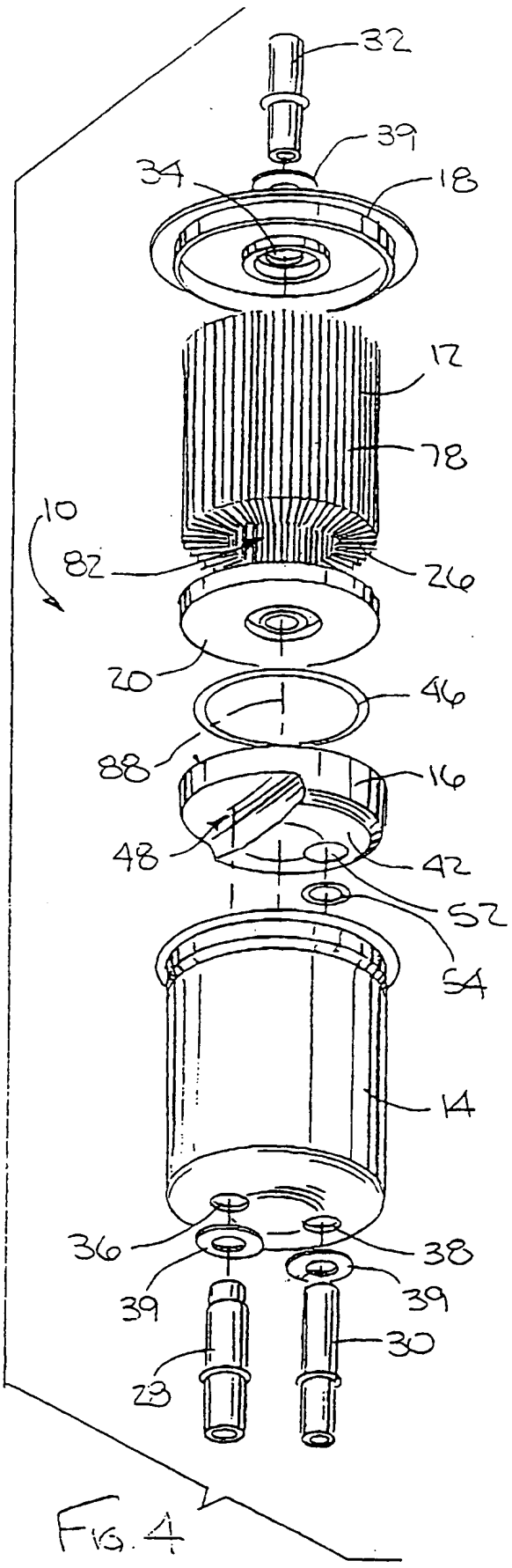
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FIG. 4

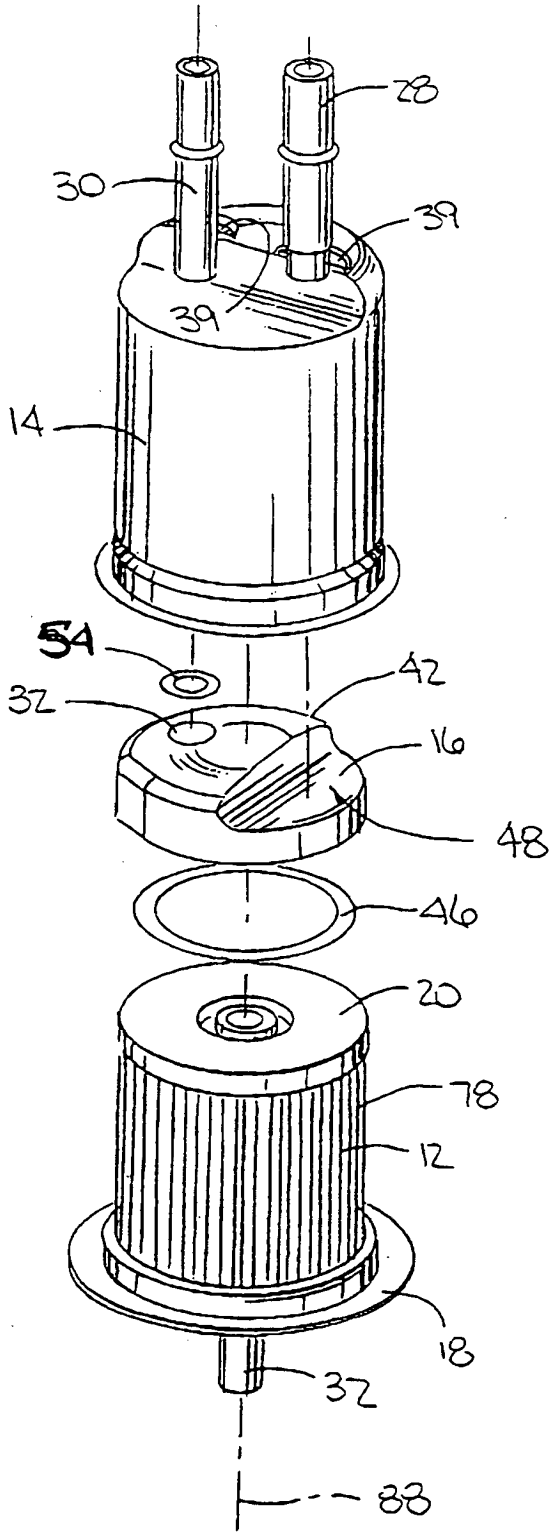

FIG. 5

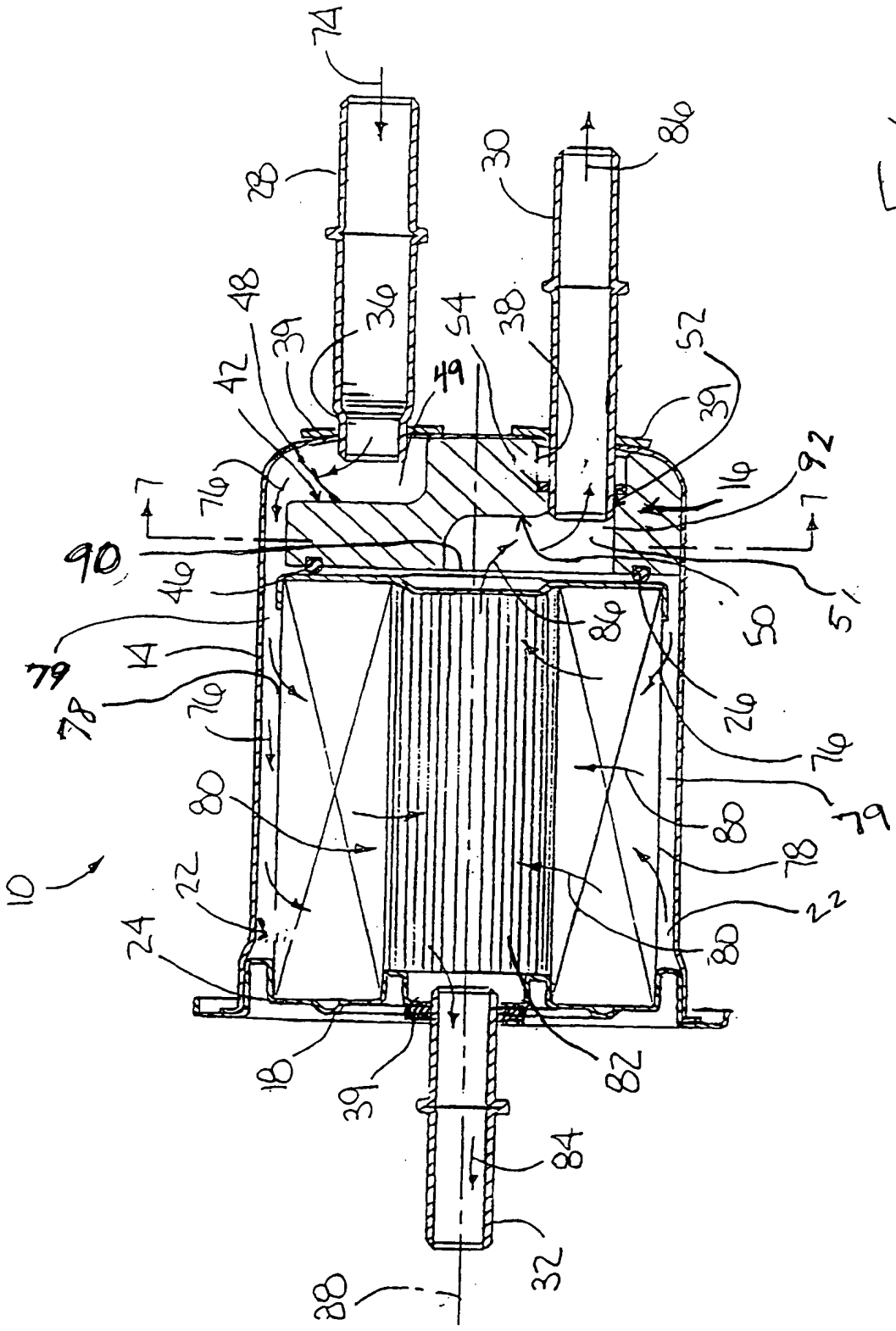

FIG. 6

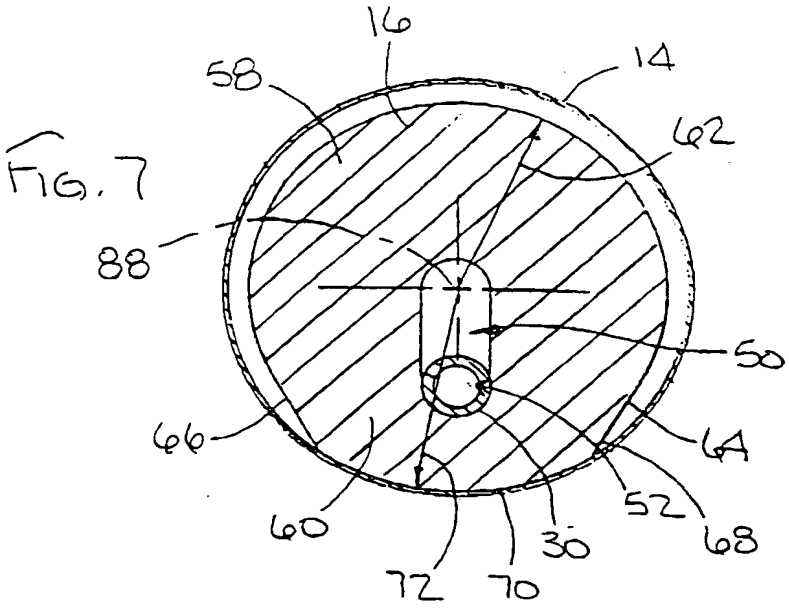

FIG. 7

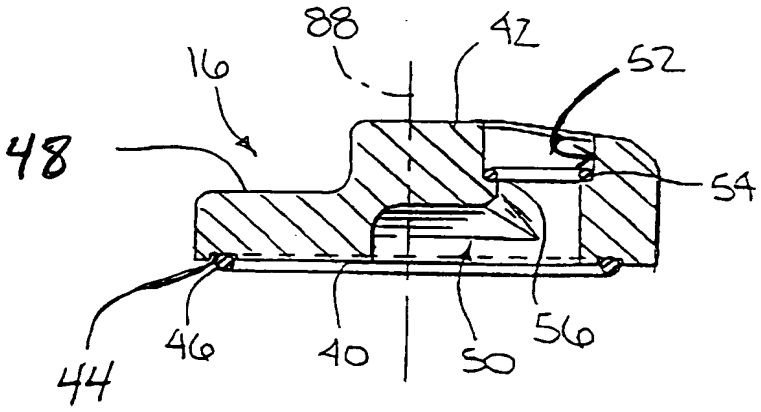

FIG. 8

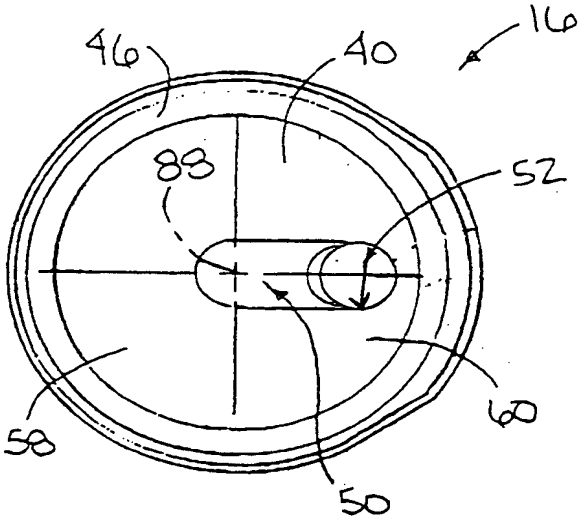

FIG. 9

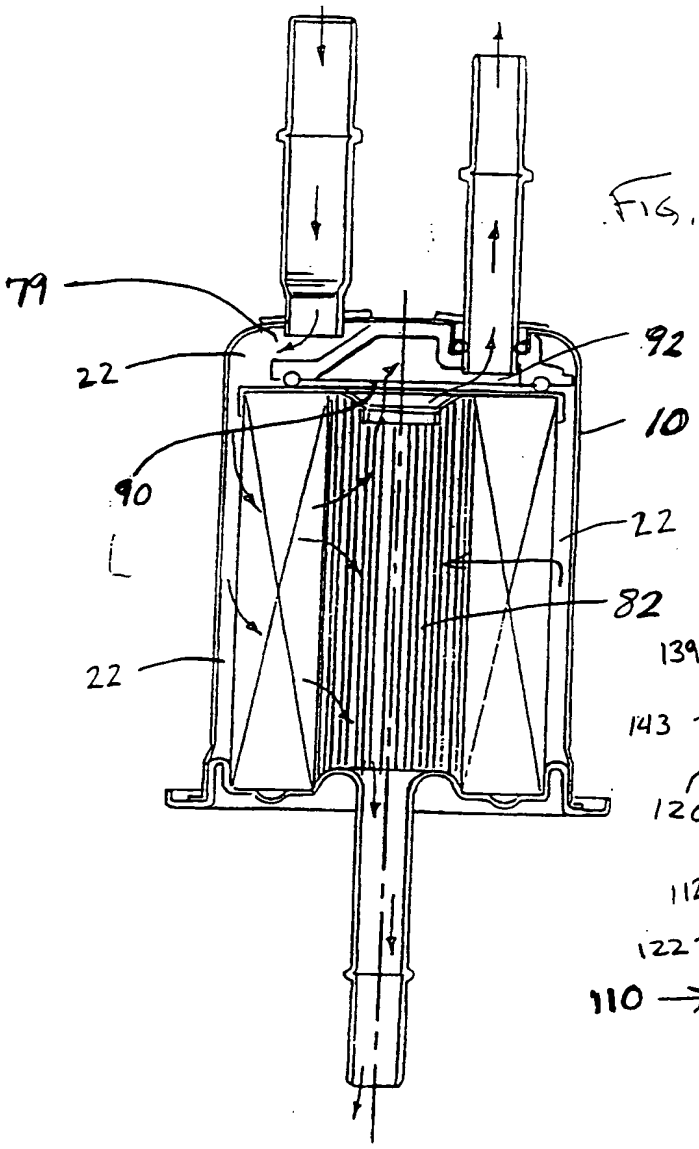
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FIG. 10

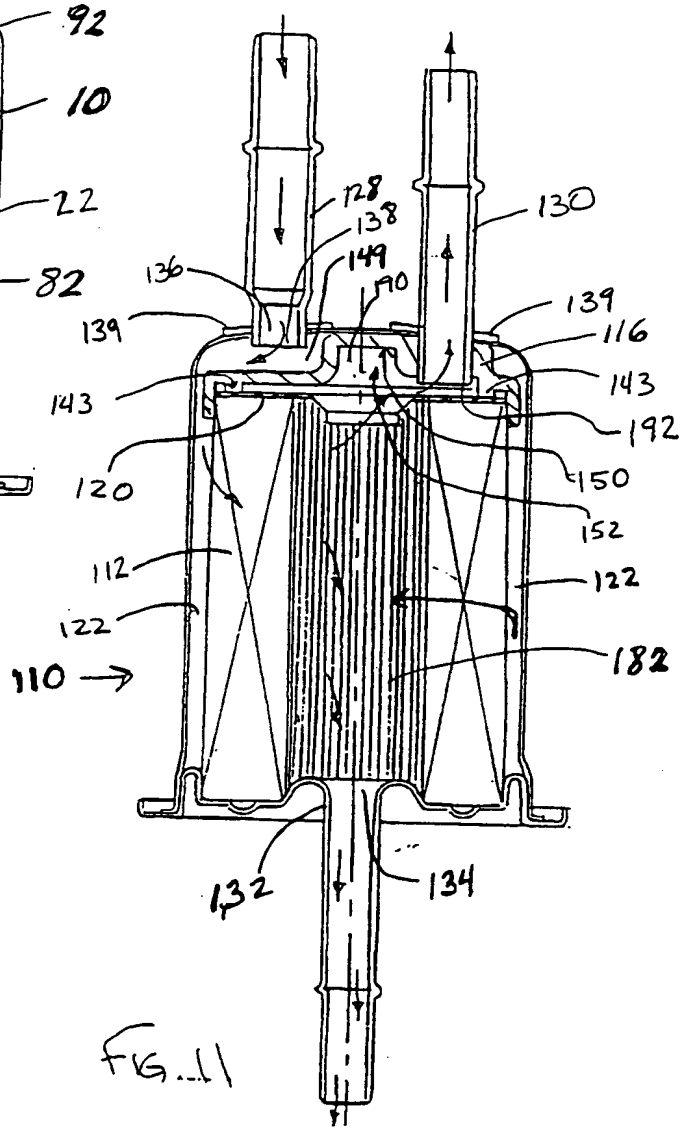
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FIG. 11

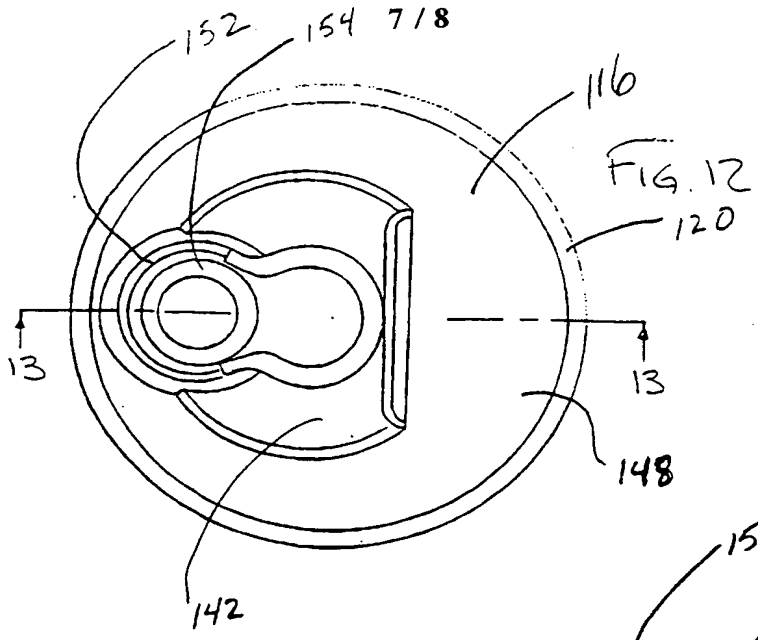

FIG. 12

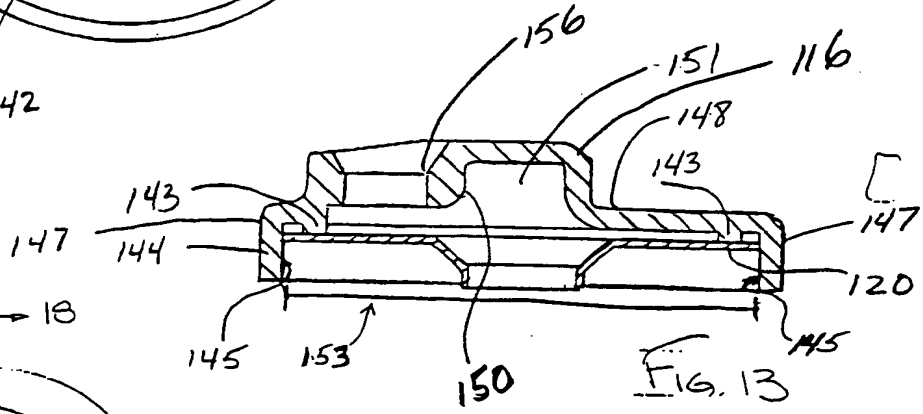

FIG. 13

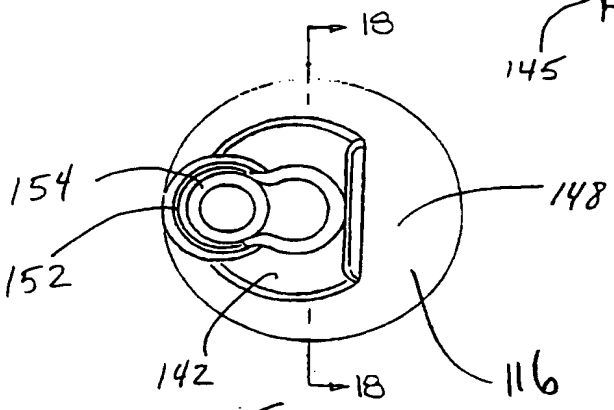

FIG. 15

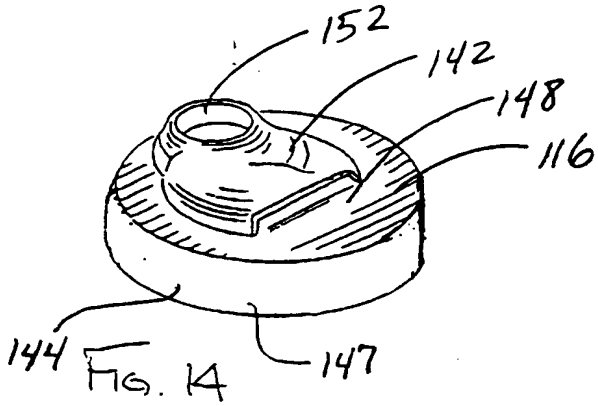

FIG. 14

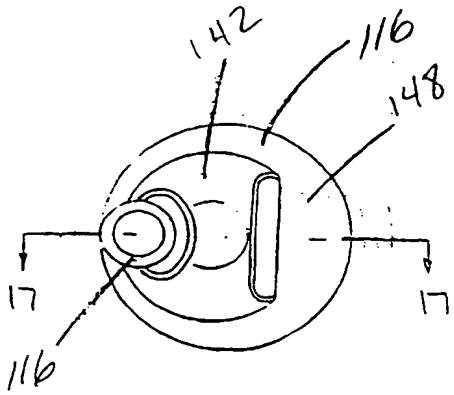

FIG. 16

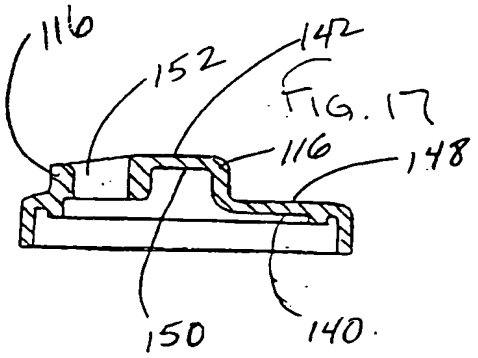

FIG. 17

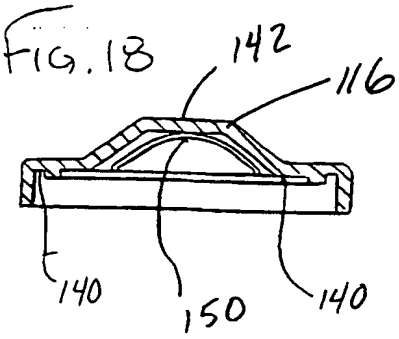

FIG. 18

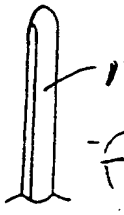

FIG. 21

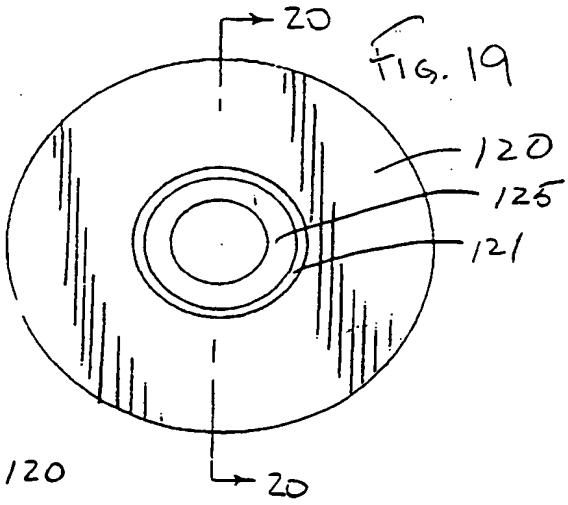

FIG. 19

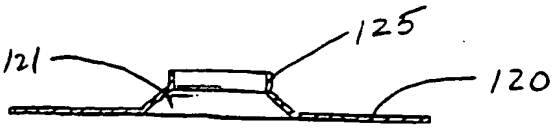

FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/29458

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) :B01D 27/08
US CL :210/440, 443, 450, 456
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 210/440, 443, 450, 456

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- A	US 2,031,935 A (CUNO) 25 February 1936, page 1, lines 10-58.	1-7, 9, 11, 13-16, and 20-22 --- 8, 10, 12, and 17-19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 05 JANUARY 2001	Date of mailing of the international search report 22 JAN 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer MATTHEW O. SAVAGE Jean Proctor Paralegal Specialist Telephone No. (703) 308-0661

Form PCT/ISA/210 (second sheet) (July 1998)★